BIOMECHANICAL ANALYSIS OF TOP TENNIS PLAYERS

Gideon Ariel, Ph.D.[1] , Vic Braden[1], Ann Penny[1], John Probe[1] ,Rudolf Buijs[1] and Alfred Finch[2]

[1]Institute for Biomechanical Research, Coto Research Center, Coto De Caza California, [2]Indiana State University, Terre Haute, Indiana, USA

The purpose of this paper was to perform kinematic analyses of some of the top players in the World during a major competition using multiple view video images that were transmitted and digitized over the Internet. Backhand and serve stroke data for Federer; Clijsters, and Aggasi were selected for the present study.

KEY WORDS: elite tennis players, tennis biomechanical analysis, Internet analysis

INTRODUCTION: Considered to be one of the great major events including the Grand Slam tournaments, the Pacific Life Open has evolved into one of the elite international sporting events in the world today. The Pacific Life Open from March 7th to March 20th 2005, hosted the most recent International Tennis Tournament with the top players in the world competing. This study evaluated the kinematics of elite tennis players stroke mechanics during a major competition using video images that were collected, transmitted, and analyzed over the Internet. Because of the limited space, only the backhand and serve stroke data for Federer, Clijsters and Aggasi are presented in this paper.

METHODS: The APAS System was utilized to collect video data from 3 stationary cameras on the field at 60 Hz. Video was transmitted automatically through Internet connection as described in Figure 1.

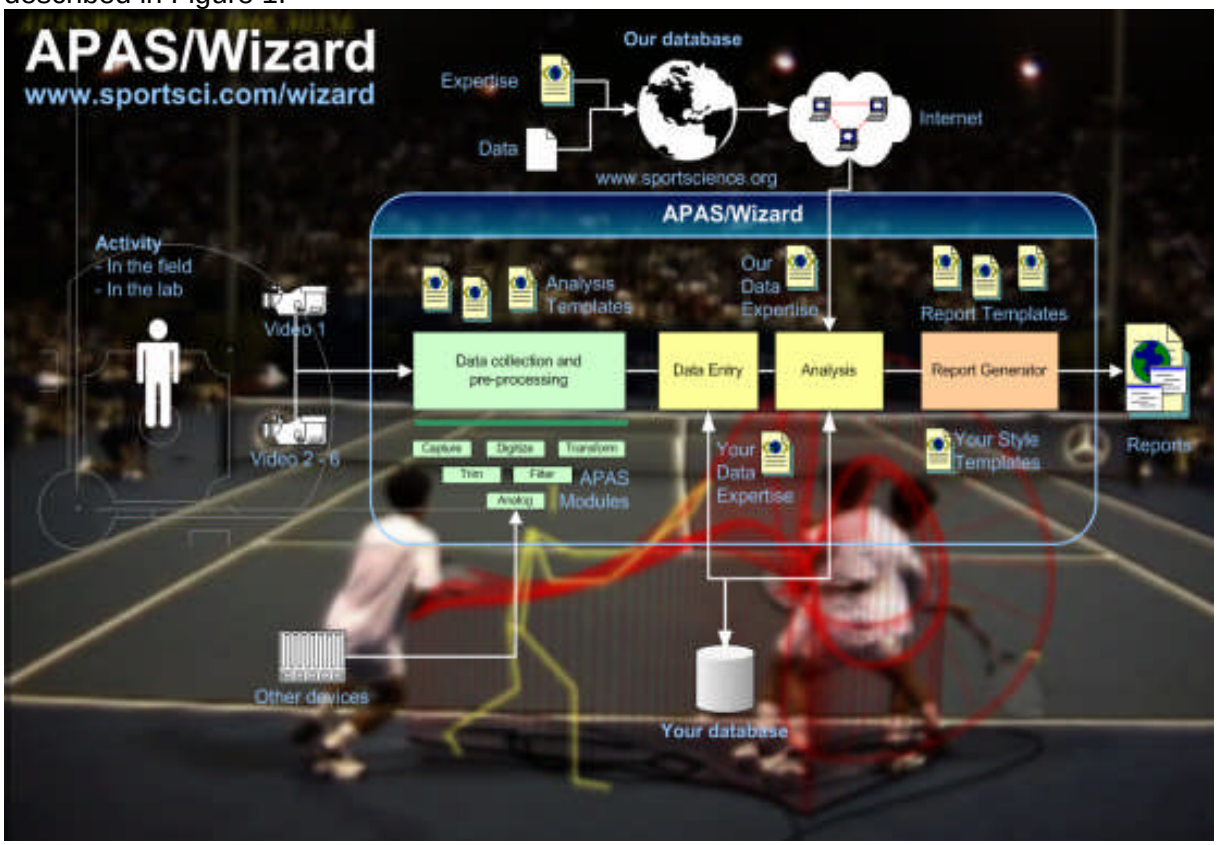


Figure 1: Data Collection and Analysis procedures.

The digitized joint centers were: feet, ankles, knees, hips, shoulders, elbows, wrists, hands, head, 6 points on the racket, and the ball.
Direct linear transformation and digital filtering at 10 Hz were utilized to calculate the 3D coordinates of each joint. Joints and segmental displacement, velocities and accelerations were then calculated. The main parameters to be analyzed for the present study were determined by one of the leading Tennis professional and coach, Mr. Vic Braden. These parameters were: velocities curves for the racquet and the ball angular velocity for the racquet and forearm. The translation phase represented the horizontal displacement of the racquet from initial ball contact to ball separation.

RESULTS: The linear velocity results for the hand, racket head, ball, and racket angular velocity for Aggasi's backhand are presented in Figure 2.

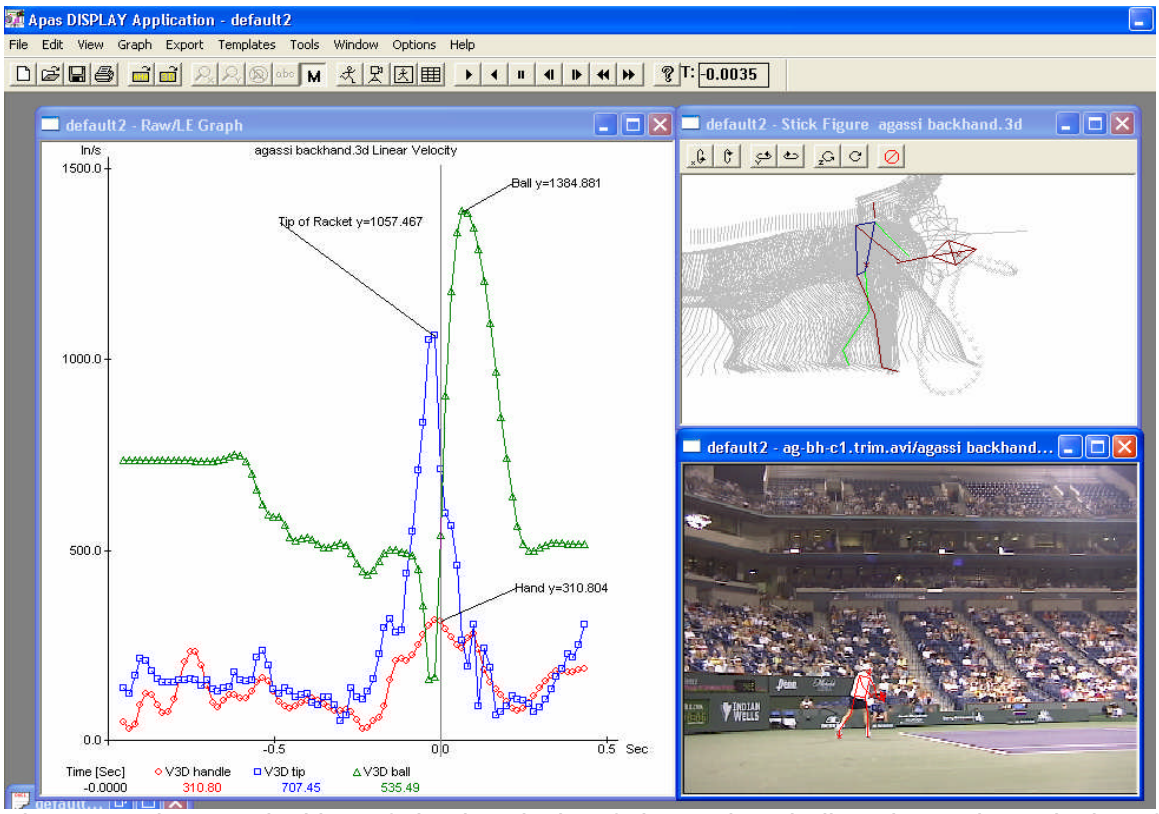
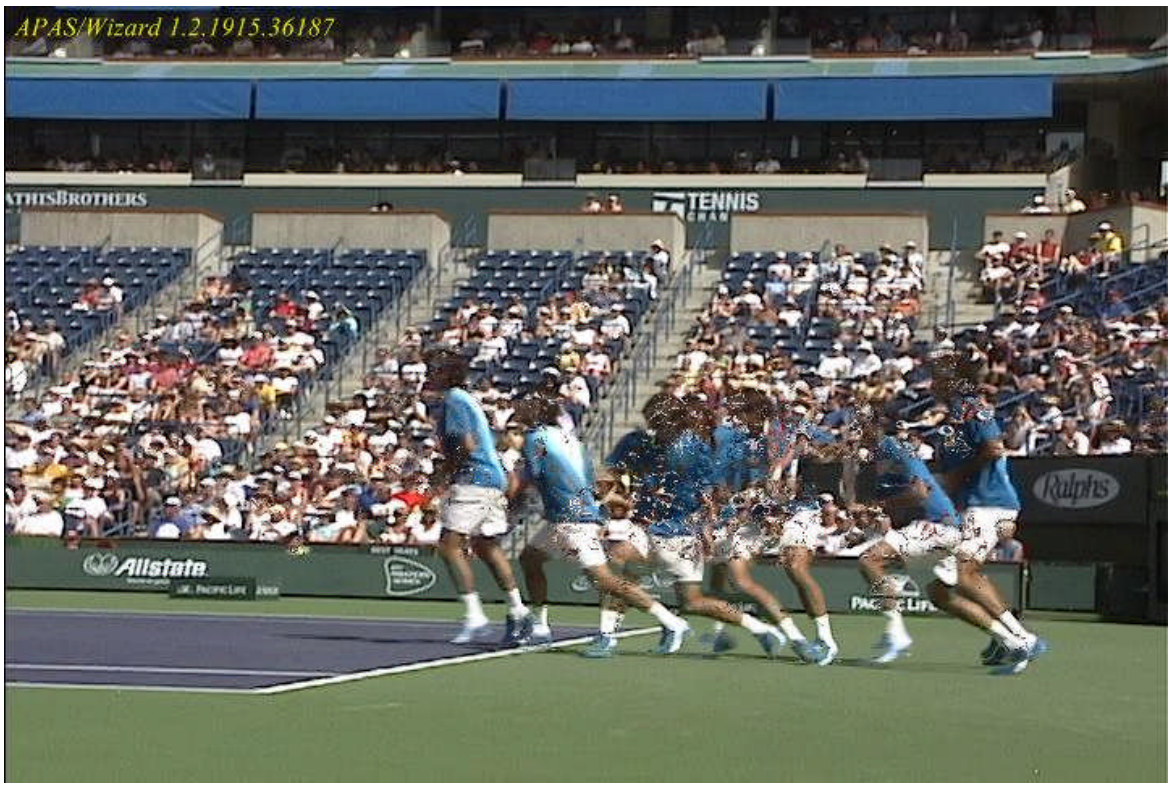


Figure 2: Linear velocities of the hand, tip of the racket, ball and angular velocity of the racket, for Aggasi's backhand.

The results for the linear and angular velocity information for Clijster's backhand and serve are presented in Figures 3 and 4, and Federer's kinematic results are presented in Figure 5.


INDIAN WELLS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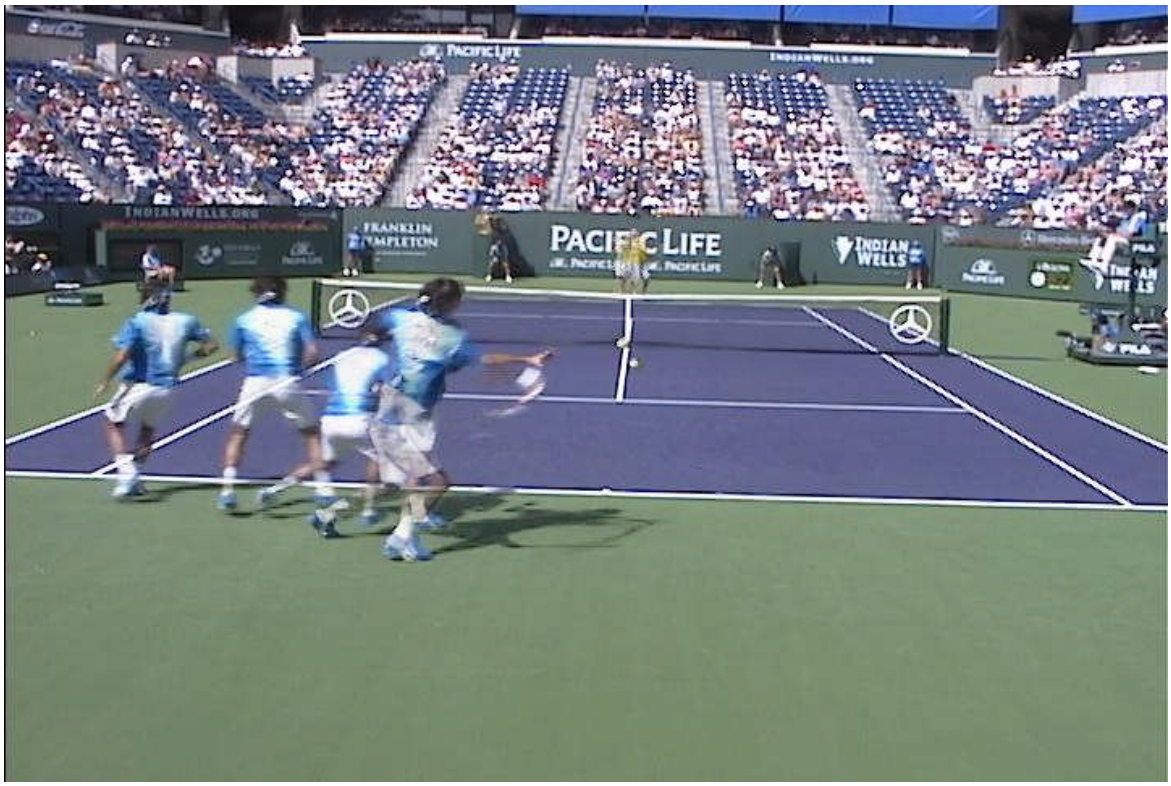
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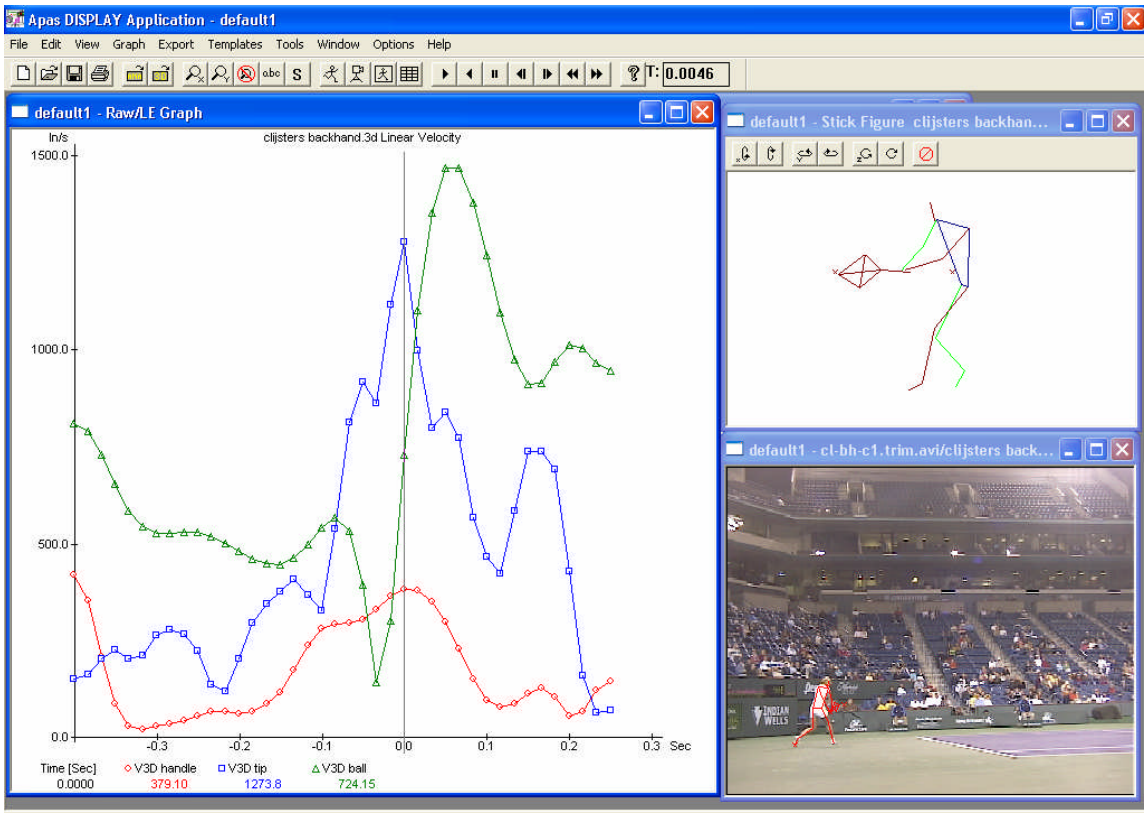

Figure 3: Linear velocities of the hand, tip of the racket, ball and angular velocity of the racket for Clijsters's backhand

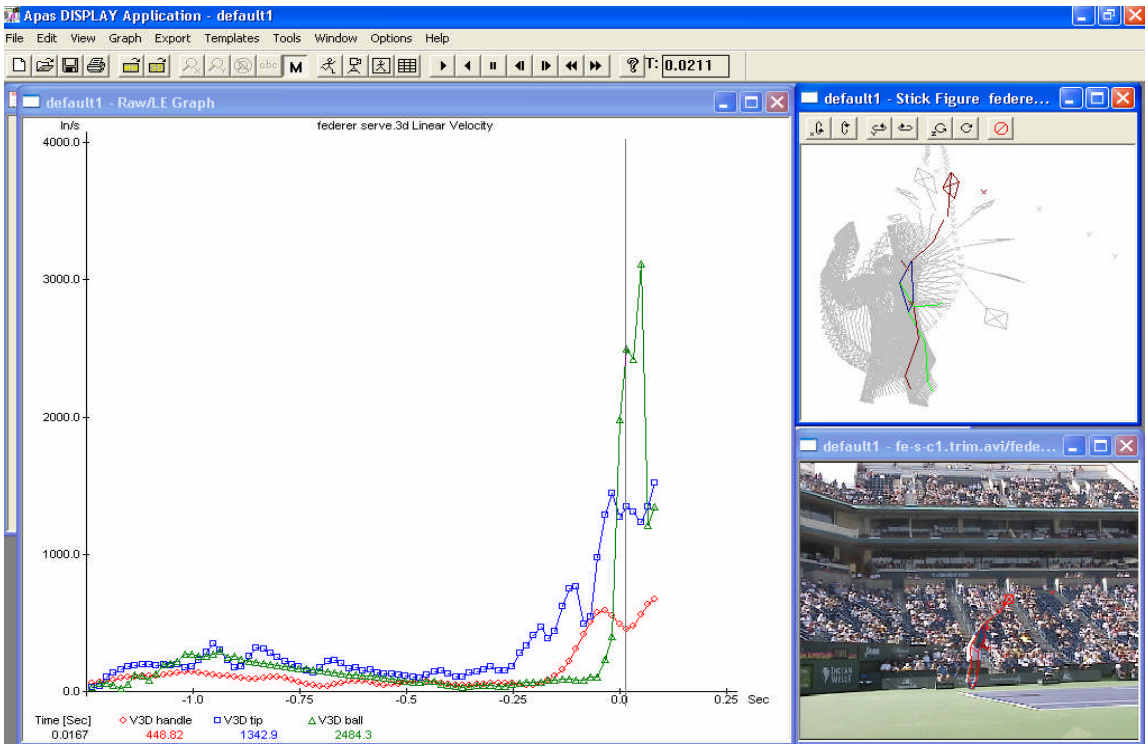

Figure 4: Linear velocities of the Hand, Tip of the Racket, Ball and Angular Velocity of the racket for Clijsters's Serve

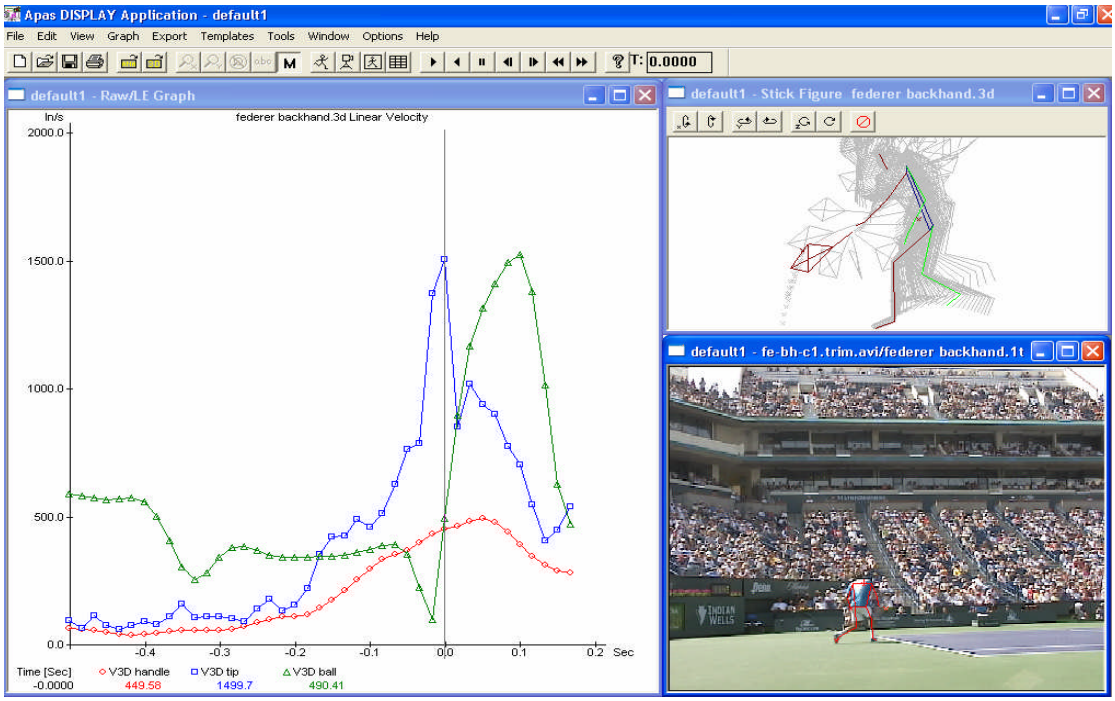

Figure 5 Linear velocities of the hand, tip of the racket, ball and angular velocity of the racket for Federer's backhand

A summary of the linear velocity alterations during the racquet interaction are presented in Table 1. During the backhand ground stroke, the hand velocity during the time interval prior to contact to after ball impact increased 25%, 0%, and 7% for Agassi, Clijsters, and Federer, respectively. During the same time period, the racquet head tip velocity decreased 72%, 13%, 27% for the same tennis players. This would indicate that the players were either recoiling or decelerating the racquet head after ball impact. As the ball interacted with the strings during the ball contact, the elastic energy that was returned to the ball resulted in ball velocity increases of 189%, 245%, and 204% for the same players. Similar increasing percentages were observed for other strokes analyzed.

Table 1 Linear velocities of the hand, tip of the racket and ball velocities prior to and after impact with the ball (km*hr^{-1}) and the peak racquet angular velocity

Player	Strokes	Hand Prior	Hand After	Tip Prior	Tip After	Ball Prior	Ball After	Peak Racket Ang. Velocity Rad*sec^{-1}	Translation Phase cm
Agassi	Backhand	22.5	28.3	96.6	27.5	43.6	126.4	46.2	35.6
Clijsters	Backhand	27.4	27.2	83.4	72.6	35.7	123.1	18.6	116.8
Clijsters	Serve	37.3	34.3	110.6	108.6	47.0	152.6	48.1	NA
Federer	Backhand	39.3	42.2	125.2	92.5	44.7	136.1	56.9	78.7
Federer	Serve	33.0	25.4	72.6	76.3	22.3	141.1	61.9	NA

CONCLUSION: The video images of elite tennis players during the Pacific Life Open tennis tournament were transmitted via the Internet, digitized, and analyzed off-site, and then selected kinematic data were shared with the athletes' coaches at the competition. Recently developed innovations in video collection, Internet transmission and analysis have provided viable means for conducting biomechanical analyses for athletic performances held at sites throughout the world. Results from such biomechanical analyses of top tennis players in a recent International tournament revealed kinematic data of the body's segments, racket and the ball velocities that could be used in coaching applications.